# Research on the Adherence of the Water-based Ink

*Fuzhong Zhang; Xianfu Wei; Beiqing Huang; Xin Li; Beijing Institute of Graphic Communication; Beijing/ China*

## Abstract

*In order to improve the adhesion of water-based ink on substrate with low surface tension. Prepare ink samples of different dispersions with different kinds of dispersants and pigment/resin ratios and test their dispersion. Then prepare different ink samples with all kinds of film-forming resins and additives, measure the surface tension of the ink samples on the plastic which is used to characterize their wettability. Meanwhile use the IGT F1 printing eligibility instrument to make proofs with ink samples above. Discuss main factors that influence adhesion of water-based ink by analyzing wettability of ink samples. Research results indicate that: dispersion of water-based ink and resin have great influences on the adhesion on substrates with low surface tension; Right amount of adhesion promoter can effectively enhance the adhesion; The well wettability of ink on the substrates is the precondition to ensure adherence of the water-based ink.*

## Introduction

The water-based ink is a kind of environment friendly printing ink which has many advantages, it has no volatile organic solvent and is nonflammable and it is favored by people gradually and applied to the area of digital printing in recent years. However, properties of water-based gravure ink such as adhesion, drying velocity and friction resistance can't meet the requirements of the digital printing, which has influenced its printability in the industry. As a result, its application on plastic hasn't been popularized yet.

Ink adhesion refers to process that ink film and substrate surface stick to each other by physical and chemical actions. Factors that affect ink film adhesion include mechanical bonding force, adsorption, diffusion and chemical bonds combination etc.

## Experiment

### Material

Pigment: permanent Bordeaux E5RK (chemical pigment company of Long yu); grinding resin: AZR acrylic resin (company of A Tuo zi in Tianjin); film-forming resin: water-based acrylic resin 2661-86-2 and 91-5 (Beijing oriental acrylic company), Joncryl 617-A, 142 and 90 (the company of BASF); dispersant: 760, defoamer: 810, wetting agent: 245, flatting agent: Glide100 (Tego additive); solvent: deionized water.

### Experimental equipments

GJ-2S digital display high speed mixer(Haitongda special instrument company in Qingdao ), electric mixer (Shanghai Si le Instrument Company); MicrotracS3500 laser particle size analyzer (America); IGT F1 printing eligibility Miriam (Holland); KRUSS surface tension meter K100(Germany); Zahn 3#;3M adhesive tape.

### Methods of experiment

Preparation of base ink: blend pigment, grinding resin, deionized water and additives and start pre-dispersion process in electric mixer 30 min and then abrade the mixture for 120 min.

The dilution of base ink: according to the requirements of gravure ink on viscosity, add the solution of dilute resin and cosolvent into the base ink and scatter them in D2004W electric mixer.

Proof making: use the IGT F1 printing eligibility Miriam to make a proof on the surface of PET, and the printing pressure and the anilox pressure is 150N and 300N respectively.

### Performance test

Viscosity test: ink viscosity is measured with Zahn 3# and takes the average value of 3 times.

Surface tension test: the surface tension of ink is tested with KRUSS surface tension meter at normal temperature.

Adhesion test: use 3M adhesive tape with a size 20mm x 20mm and cover it on proofs with ink cell depth of 48 μm, put a card that has 100 squares under proof, pull tape at 90° with constant tension from plastic surface, calculate percentage of squares covered with remaining ink of total squares, the bigger percentage is, the better ink adhesion is and take them as standard of adhesion test.

## Results and discussions

### Influence of pigment/resin ratio on ink adhesion

The base ink's disperse state is differ with the change of pigment/resin ratio, so is adhesion of ink samples on plastic. In order to make a study on influence of pigment/resin ratio on adhesion of ink, prepare base ink samples with AZR acrylic resin and different pigment/resin ratios, test their particle size and then prepare ink with film-forming resin, make proofs and test the adhesion. Results are shown in figure 1.

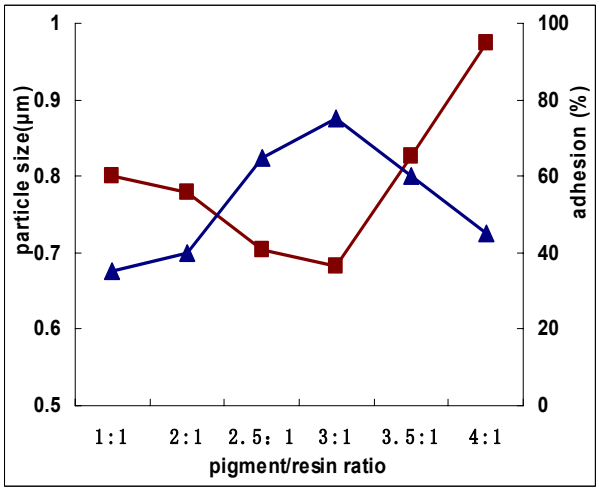


***Figure 1:*** *influence of pigment/resin ratio on adhesion of water-based ink on plastic (■:particle size, ▲:adhesion)*

It can be seen from figure 1 that pigment/resin ratio influences the ink adhesion on plastic greatly, adhesion of ink on plastic increases firstly and then decreases as the growth of pigment/resin ratio, which there is variety on it, so is the disperity and adhesion.

The better the disperity is, the better the adhesion is. Ink has highest adhesion and smallest size when pigment/resin ratio is 3:1; it also has high cohesion on attachment on plastic and best adhesion on plastic.

### *Influence of film-forming resin on adhesion*

The function of film-forming resin is to protect ink film and rely on polar groups of structure to generate some adhesion with substrate. Since the structure of film-forming resin is different, the combination between ink and plastic will be different, so is the adhesion between ink and substrate.

The film-forming resin used in water-based ink is acrylic resin which adheres to surface of plastic by Vander Waal's force. Majorities of acrylic resin molecules form hydrogen bonds with polar groups on surface so as to improve adhesion.

Different acrylic resins have different quantity of polar groups, the bigger the quantity is, the better adhesion is. Prepare inks with different kinds of film-forming resins, make proofs and test the adhesion. Outcomes are shown in figure 2:

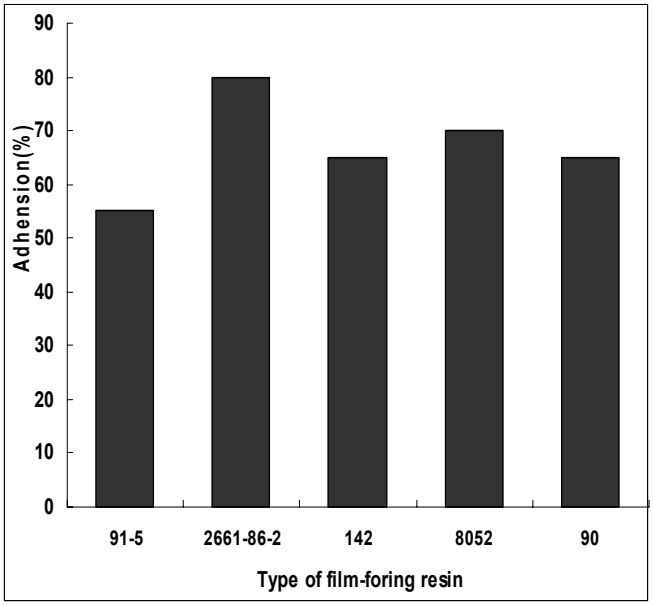


***Figure 2**: influence of different film-forming resin on adhesion of water-based ink on plastic*

Fig.2 shows that film-forming resin has a great effect on the adhesion of ink. Inks prepared with acrylic resin 2661-86-2 have best adhesion on plastic but other resins don't have ideal results. This is probably because 617-A is a kind of resin with more polar groups, which can promote the combination with the polar groups of plastic and improve adhesion.

## *Influence of additives on adhesion*

### *Influence of dispersant on adhesion*

Dispersant is a kind of surfactant that reduces the aggregation extent of pigment particles to make the mixture be dispersion and suspension easily to keep the dispersant stable. The addition of dispersant decreases the thermodynamic instability of ink and the distribution of pigment particles in system is more stable, the adhesion is stronger when the ink is transferred to surface of plastic. Change the content of dispersant to prepare base ink samples and test the particle size and the adhesion. Experiment results are shown in figure 3:

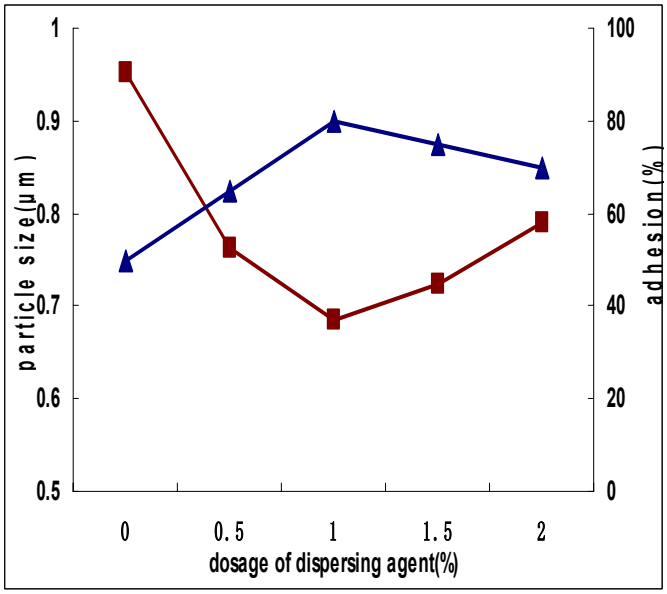


***Figure 3**: influence of dosage of dispersant on adherence (■: particle size ▲: adhesion)*

As is shown in figure 3, while dosage of dispersant is low, adhesion of ink rises with the increase of dosage of dispersant and reaches its biggest value about 80% in the dosage of 1%, At this time, the pigment particles have larger space steric effect and is dispersed in base ink uniformed and steady, ink samples have best adhesion on surface of plastic after dilution with film-forming resin, then adhesion reduces slightly as the dosage of dispersant keeps increasing.

It can also be seen from figure that particle size becomes small as the increase of dosage of dispersant, as a result of decrease of the particle size, the roughness of ink surface downs gradually which reduces contact area between ink film and plastic so that to decrease tear strength of tape, in the end, ink adhesion is improved.

### *Influence of wetting agent on adhesion*

Water-based ink use water as solvent, whose polarity and surface tension are higher than common organic solvents, surface tension is an important factor that influences adhesion, wetting agent is surfactant which is made of hydrophilic groups and lipophilic groups, when contacted with surface, lipophilic groups stick to surface while hydrophilic groups jut out into liquid, so as

to form a continuous phase of liquid on surface, we call it the fundamental principles in wetting action.

Prepare ink samples with different contents of wetting agent and test adhesion of ink samples. The experimental results are shown in figure 4:

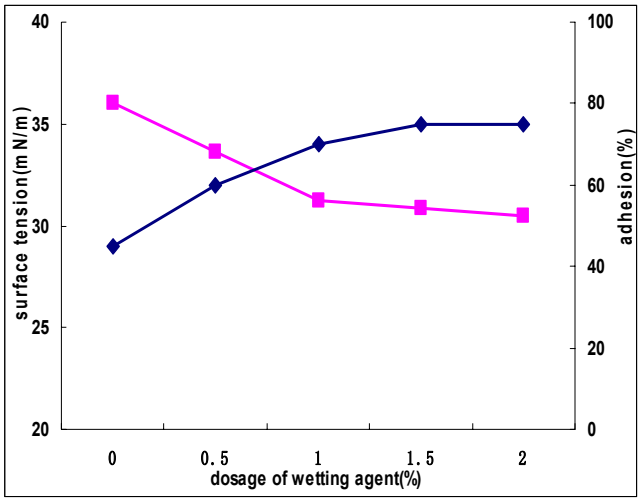


***Figure 4****: influence of wetting agent on adhesion of water-based ink on plastic*

As is shown in figure 4 that the addition of wetting agent can improve adhesion of ink on plastic remarkably, surface tension of ink samples decrease gradually with the increase of addition of wetting agent from 36.067mN/m to30.495mN/m, adhesion of ink on plastic surface rises from 40% to its biggest value 80% in the dosage of 1.5%, afterwards adhesion had no notable change.

The existence of wetting agent can reduce surface tension of ink effectively and let the ink spread on plastic well so as to improve adhesion of ink samples and wet the plastic surface effectively.

Thus increase the chance that the ink contact with plastic film to generate stronger adhesion. The lower the surface tension of ink samples is, the higher the efficiency of wetting action is, so that, the adhesion is better; However, the surface tension of ink don't change any more when the content of 245 exceeds 1.5%, instead, they form micelles inside the liquid to let the properties of liquid change, as a result, adhesion of ink samples will not change any more.

### *Influence of isopropyl alcohol on adhesion*

Isopropyl alcohol is a kind of small molecule of alcohol solvent whose scientific name is 2 – propanol. It can reduce the surface tension and promote the adhesion of the water-based ink system. In order to research the relationship between dosage of isopropyl alcohol and adhesion, prepare base ink samples with different contents of isopropyl alcohol and print them on surface of plastic, measure the adhesion. The relationship between dosage of isopropyl alcohol and adhesion is shown in figure 5:

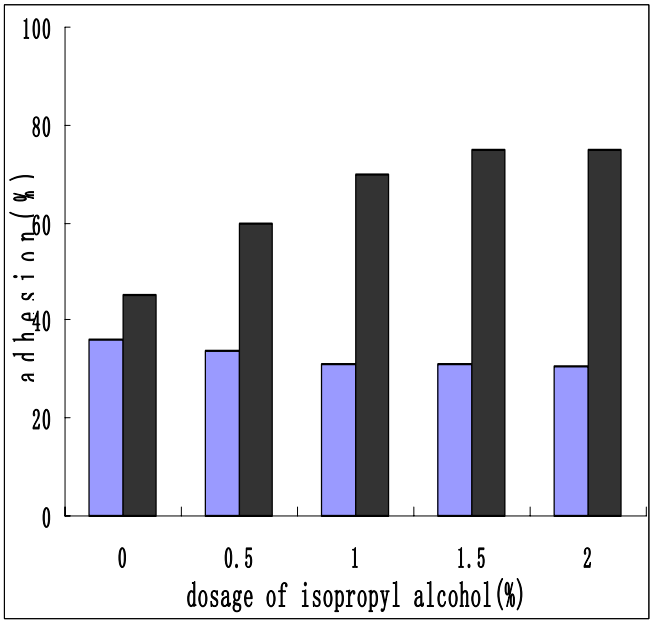


***Figure 5****: influence of isopropyl alcohol on adhesion of water-based ink on plastic (■: surface tension: ■adhesion)*

As is shown in figure 5 that when is printed on surface of plastic and content of isopropyl alcohol from 0.5% to 1.5%, the adhesion of ink is improved and reaches its biggest value at the content of 1.5%. However, the adhesion of ink keeps the same at the dosage of 2%.

We can consider that the existence of isopropyl alcohol can reduce surface tension of ink samples and let the ink spread on plastic surface well in order to improve adhesion of ink samples and wet the plastic surface effectively.

The lower the surface tension of ink samples is, the higher the efficiency of wetting action is, so that, the adhesion is better; However, the surface tension of ink don't change any more when the content of isopropyl alcohol exceeds 1.5%, the adhesion does not change any more.

## Conclusion

1) Dispersion of the system has influences on the ink adhesion on plastic; the ink has best disperity and adhesion on plastic when pigment/resin ratio is 3:1 and the content of dispersant is 1% as well as with the use of AZR acrylic resin as grinding resin.

2) The kinds of film-forming resin are key factors that affect the adhesion of ink on surface of plastic. The ink has its best adhesion on surface of plastic when acrylic resin 2661-86-2 is used as film-forming resin in the ingredients. The best adhesion of ink on surface of plastic is 80%.

3) The addition of wetting agent and isopropyl alcohol can reduce surface tension of ink effectively and let the ink spread on plastic well so as to improve adhesion of ink samples. The lower the surface tension of ink samples is, the easier the ink could spread on plastic. Adhesion of ink on plastic surface has its biggest value 80% in the dosage of 245 and isopropyl alcohol is at 1.5%.

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## Acknowledgement

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## Author Biography

*Fuzhong Zhang, a postgraduate comes from Printing and Packaging Engineering college in Beijing Institute of Graphic Communication, China .I'm majoring in printing engineering in my undergraduate period and printing materials water-based gravure ink on tipping paper and plastic which is a kind of environmental friendly ink that has no harm to people in my postgraduate period.*